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ABSTRACT

Recent developments for student assessment and national curriculum in England are presented in this paper. The first part offers an overview of the national curriculum, as established by the government-appointed Task Group on Assessment and Testing (TGAT), which identified corresponding levels with statements of attainment. National curriculum assessment, as proposed by the TGAT, led to the development of the Standard Assessment Task instrument in 1991. The role of national curriculum assessment in reporting results is also described. Conclusions are that aggregated judgments of performance pose problems for true criterion-referencing, and that no evidence currently exists as to the effect of curriculum specifications on teaching and learning. Assessment validity is threatened when assessment practices and the curriculum are not changed in conjunction with each other. The appendix (Attainment Target 4: Shape and Space) provides a sample program of study. (8 references) (LMI)

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LINKAGES BETWEEN NEW CRITERIA AND CURRICULUM DEVELOPMENT

by

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INTRODUCTION

At the point of the measurement of any indicator, we have to face up to two validity issues: the relationship between the concept underlying the indicator and its operationalization, and the relationship between the operational definition and the actual measures. These two validity issues are particularly acute in the case of high-inference indicators such as outcomes of education, especially student achievement.

DEFINING STUDENT ACHIEVEMENT

Student achievement can be represented as the desired outcomes of the taught curriculum or, more broadly, as the (desirable) outcomes of the learning that has taken place during youth, whether this arises from extra-curricular school activities, the hidden curriculum of the school or life outside school. Both approaches are seen in systems for monitoring national standards. For example, Scotland tests only English, mathematics and science, and Finland only mathematics, science and Finnish/Swedish. The Netherlands has broader curriculum coverage, including traffic education, as does Spain (Spanish language, mathematics, social sciences, experimental sciences, English and French) but Spain goes further by including aptitudes and civic/social science attitudes (Binkley et al, 1991).

The range of subjects and skills tested is also extensive in France. While the grade 3 and 6 population surveys are restricted to mathematics (including problem solving) and French (reading, writing, vocabulary, grammar and spelling), the sample surveys have also covered (on one or more occasions) English, German, physical sciences, history, geography, technology and school life. This last usually embraces three broad topics (in questionnaires answered by students, teachers and principals):

> The first concerns fitting into school life and endeavours to analyse a pupil's experience - with the collège, for example, being viewed as a community (community relations, rules and constraints) and as a formative environment (how teaching is accepted and perceived, assessment, family back-up, homework organization and the general contribution of the collège to the pupil's education). The second topic focuses on adjustment to community conditions and awareness of the outside world; it examines such things as responsiveness to community living (joining in groups), initiative and

leadership. The third is more directly centred on preparation for the future, ie, the information sought, received and absorbed by pupils; the development of career ambitions; the effectiveness of pupil counselling and observation.
(Le Guen 1991, p 15)

The Assessment of Performance Unit (APU) in England and Wales had ambitious plans. At the time of its establishment (1976), there was no prescribed national curriculum; the APU's conceptualization of the curriculum was in six broad areas: language development (including foreign languages), mathematical development, scientific development, aesthetic development, physical development and ethical development. The framework was not universally welcomed - where did the humanities and the social sciences fit? - and technology was later added. Development of all elements of the framework took place, together with reviews of possible testing methods, but in the event testing did not go ahead in the aesthetic, physical and ethical lines of development.

In those lines where testing did go ahead (ie English and foreign languages, mathematics, science and technology), the definition of each domain was deliberately kept broad, with a topic coverage greater than expected in any one school. Some topics were almost universal but others might appear in the curricula of only a minority (albeit a substantial minority) of schools. A broad coverage of skills, including practical, oral and problem-solving skills, was also encouraged. As a consequence, assessment methods were also diverse; many of the observational, practical and performance tasks were administered to individual students (or sometimes pairs of students) by specially trained peripatetic testers, who also assessed the students' performance. The cost of assessment per student was thus often high. (An early evaluation of the work of the APU was conducted by Gipps and Goldstein 1983; a summary of its experiences up to its demise in 1990 is given by Foxman et al 1991.)

REPRESENTING STUDENT ACHIEVEMENT

Once the coverage of the achievement domain is agreed, the achievement within a particular subject or field has to be defined more closely. For public examinations in England, the traditional method was by listing topics (which were elucidated through

teachers' careful study of previous examination papers) but the movement initiated by Tyler to specify achievement in terms of behavioural objectives has now influenced not only England, but the whole world. There are, of course, critics of the whole notion of behavioural objectives (eg Stenhouse, 1975), on the grounds of their lack of flexibility and responsiveness, that they fail to give a holistic portrayal and that they inadequately represent higher-order abilities. Despite these criticisms, behavioural objectives and their close relations, criteria (as in criterion-referencing) and standards, dominate curriculum specification in the English-speaking world (and in many other countries). This is well exemplified in the National Curriculum in England.

THE NATIONAL CURRICULUM IN ENGLAND

The National Curriculum comprises three core subjects (English, mathematics and science) and six other foundation subjects (technology, geography, history, art, music and physical education). Religious education also remains a compulsory subject (to age 16, the end of compulsory schooling); in addition, at the age of 11 (the normal age for starting secondary education), a modern foreign language becomes part of the National Curriculum. The detailed content of each subject is prescribed (in the manner described below) and further guidance about suitable teaching and learning activities is also given at national and local level.

The manner in which the National Curriculum is specified was established by the Government-appointed Task Group on Assessment and Testing (TGAT), who realised that the principles of the curriculum specification and of the assessment specification had to be devised simultaneously. One of their cardinal principles was that the system should be criterion-referenced, and that the curriculum should therefore be in terms of an explicit definition of what a student should be able to know, understand and do. The group drew on the experience of graded testing, a ladder of grades up which a student could progress at his or her own pace, common in music, ballet and other physical activities, and imported into the mainstream curriculum for subjects like modern languages, mathematics and science in the last 15 years or so (Pennycuick & Murphy, 1988). TGAT recommended that, for each subject, there should be ten levels of attainment spanning the ages of compulsory schooling (five to sixteen). These would be anchored such that the performance of a "typical" 7-year-old would be at level 2 and would improve by one level every two years.

Working parties, consisting largely of educationists, were set up in each subject to develop a curriculum adhering to this framework. Each subject was to be conceived of as comprising a series of major domains (usually about five), known as attainment targets. Within each attainment target, ten performance levels were defined (by the best judgement of the group) in the form of statements of attainment. An example (one of the briefest available) for History Attainment Target 3 (The use of historical sources) is given below:

Level	Statements of Attainment
	Demonstrating their knowledge of the historical content in the programmes of study, pupils should be able to:
1	communicate information acquired from an historical source.
2	recognise that historical sources can stimulate and help answer questions about the past.
3	make deductions from historical sources.
4	put together information drawn from different historical sources.
5	comment on the usefulness of an historical source by reference to its content, as evidence for a particular enquiry.
6	compare the usefulness of different historical sources as evidence for a particular enquiry.
7	make judgements about the reliability and value of historical sources by reference to the circumstances in which they were produced.
8	show how a source which is unreliable can nevertheless be useful.
9	show an understanding that a source can be more or less valuable depending on the questions asked of it.

10 explain the problematic nature of historical evidence, showing an awareness that judgements based on historical sources may well be provisional.

Attainment targets can also be grouped into profile components below the level of the subject (eg English Profile Component 3 comprises three attainment targets, Writing, Spelling and Handwriting). The attainment targets are usually illustrated with examples, and linked to more detailed programmes of study (as illustrated in the Appendix to this paper).

The Task Group on Assessment and Testing stressed the value of formative assessment (to guide teaching and learning on a day-to-day basis) but was charged to design a system that would also provide summative assessment at the end of key stages (the Government later adding informative assessment, ie providing information to parents about their child's progress), and evaluative assessment by aggregating students' performance to the level of the classroom or the school, to allow class and class or school and school to be compared. Aggregation to higher levels, including the nation as a whole, was also required.

NATIONAL CURRICULUM ASSESSMENT

TGAT proposed that the bulk of National Curriculum Assessment could be carried out by teachers in their own classrooms. This heralded the way to designing assessment tasks for children that could be naturalistic, part of the daily routine of the classroom rather than a special event, and thus not creating anxiety in children, especially those aged 7. This strategy therefore encouraged the creation of performance tasks (practical, oral or written). Thus was the Standard Assessment Task born, building especially on the experience of the APU in imaginative ways. The APU has now been closed down since the new National Curriculum Assessment is expected to give the same information and more.

The Standard Assessment Task (more properly, the set of tasks) used in summer 1991 was made available to teachers several weeks before the administration period, to allow them to become familiar with the range of tasks required (both of them and of the children) and to encourage them to plan normal teaching activities that would make the assessment tasks arise naturally. It was estimated that three weeks would be needed to administer

all the tasks to all the children in a typical class. The administration could be spread over a period of six weeks if the teacher desired, and the teacher was encouraged to introduce the tasks in his or her own words.

The tasks themselves varied in mode of presentation and response, though the oral mode was most common. Many tasks were specific to a level (levels 1 to 3) and instructions were given on how children could enter at a high level, or be routed back to normal teaching if a particular task was clearly beyond them. There were writing tasks in English. In mathematics, one of the tasks (for a group of four children) was to devise their own game (dice and counters were provided). Another activity ("shopping") allowed assessment of basic number skills. In science, there was assessment of basic knowledge and understanding (eg names of parts of the body, life cycle). There was also a substantial practical activity on floating and sinking to test children's understanding of experimentation.

During the trials of the tasks in 1990, and in a full-scale pilot run in 1991, the tasks for 7-year-olds were found interesting for teaching, learning and assessment purposes, but totally unmanageable in the practical sense for most teachers. Making a careful assessment by observation of the practical and intellectual behaviour of a group of six children aged 7, while at the same time keeping the other 24 children usefully occupied, was clearly impossible.

Largely as a result of these management problems (but also partly as a result of political mistrust of teachers' judgements), the 1992 Standard Assessment Task contained far fewer performance activities and individual testing and far more conventional group paper-and-pencil testing. The 1992 testing at age 14 will also largely be through conventional assessment methods.

Aggregating results

TGAT saw the Tasks as being the lynch-pin of the National Curriculum Assessment system, especially as a device for spreading good practice about ways of assessing students and as a device for helping teachers to understand the standards and to interpret them uniformly. But the Standard Assessment Tasks could only sample the achievements of individual children, and a more rounded, more valid and perhaps more reliable assessment

of the child could be derived from the teacher's own accumulated experience of the child's achievements over a period of nearly one year. This assessment is known as Teacher Assessment (TA). While TA is arguably much more valid and comprehensive than a Standard Assessment Task, it is perhaps more prone to unwitting bias, unreliability and divergence from national standards. So the Government decided that performance on the standardized sample of achievements (the tasks) should over-rule the teacher's cumulative assessment (subject to an appeal by the teacher to a moderator in certain prescribed circumstances), where both take place. The 1990 trials at Key Stage 1 required task assessment of some 30 separate attainment targets - categorically impossible, said the teachers after their experience in the trials. So the task was simplified to assess only nine of the targets; the remainder were assessed only by TA. Moreover, in years not corresponding to the end of key stages, TA yields information that is reported to parents.

To make a judgement about which level a child has reached in a given attainment target, a composite judgement may well be required. Take, for example, the statements of attainment for the first three levels of English Attainment Target 3 (Writing):

Level	Statements of Attainment
	Pupils should be able to:
1	a) use pictures, symbols or isolated letters, words or phrases to communicate meaning.
2	a) produce, independently, pieces of writing using complete sentences, some of them demarcated with capital letters and full stops or question marks.
	b) structure sequences of real or imagined events coherently in chronological accounts.
	c) write stories showing an understanding of the rudiments of story structure by establishing an opening, characters, and one or more events.
	d) produce simple, coherent non-chronological writing.

3 a) produce, independently, pieces of writing using complete sentences, mainly demarcated with capital letters and full stops or question marks.

b) shape chronological writing, beginning to use a wider range of sentence connectives than "and" and "then".

c) write more complex stories with detail beyond simple events and with a defined ending.

d) produce a range of types of non-chronological writing.

e) begin to revise and redraft in discussion with the teacher, other adults, or other children in the class, paying attention to meaning and clarity as well as checking for matters such as correct and consistent use of tenses and pronouns.

Each level contains several statements (known as strands); moreover, within strands there may be more than one attribute (eg 2 (d) where the non-chronological writing must be "simple" and "coherent"). With multiple strands, it has been decided that the statements of attainment for a given level will be satisfied if the student has successfully achieved (N - 1) strands when the level contains N strands (when N is greater than one). This applies both to TA and to the Standard Assessment Task.

After the Standard Assessment Task result is combined with the TA result for each attainment target, the next combination is of the attainment target levels into a level for the profile component. A profile component consisting of four attainment targets will have its level determined by a simple algorithm: for example, a student at level 1 in three of the targets and at level 2 in the fourth will be judged a level 1 in the profile component; another with two level 1s and two 2s is judged as level 2 on the profile component. (In essence, the median is derived and rounded to the nearest integer.) Then, finally as far as the individual child is concerned, the profile component levels have to be combined to provide a level for the subject as a whole (using weighted means rounded to the nearest integer). So if a 7-year-old is at level 2 in English, what can be deduced? She is certainly a typical 7-year-old, since some 60-70 per cent of her peers will also be level 2. What more? The criterion-referencing at the level of statements of

attainment within attainment targets may be a little crude but still useful to the teacher. All other criterion-referencing has been lost: our 7-year-old might be at level 1 in one profile component, and at level 3 in another, and, within a profile component, at level 1 in one attainment target and at level 3 in another. There is no way that we can deduce the standard she has achieved in Writing or in Reading. She could be at least two years (one level equals two years of normal progress) ahead of a typical 7-year-old in Reading, and two years behind the typical 7-year-old in Writing, despite the fact that she was a typical 7-year-old in terms of her English attainment.

Reporting results

The primary purpose of NCA is to provide more information about education and educational progress to the public in general and particularly to parents of children at school. There is a variety of information available (at the level of attainment target, profile component and subject). Teachers and many parents would want information at the attainment target level or even at the statement of attainment level (where, arguably at least, criterion-referencing is achieved, and provides information useful to planning the next stages in teaching, be they remedial, just a matter of more practice, or moving on to a more advanced topic). Others, such as most parents and the public, would want more of a summary of the information. There is no shortage of information available: levels for 14 attainment targets in mathematics alone, plus 17 in science (covering perhaps double or triple the number of statements of attainment) in 1991 and 1992. These 31 attainment targets provided so much information and, more significantly, required so much assessment and testing that after only two years of trials the Government ordered that they should be reduced to five or fewer for each subject. The information available from 1993 will therefore be as follows: scores on 5 attainment targets and 1 subject score in mathematics, 4 and 1 in science, 5 and 1 in English (plus 3 profile component scores), 5 and 1 in technology (plus 2 profile component scores), 3 and 1 in history and 5 and 1 in geography (the exact structures of the other subjects and their assessment arrangements not having been agreed at the time of writing). An example of a new Mathematics attainment target is shown in the Appendix.

Aggregated information for each subject and for each school as a whole will have to be published, except for results at age 7 to acknowledge the many influences other than the infant school on attainment at that age. The Secretary of State for Education and Science

will, however, be strongly encouraging these schools to publish their results. There is much debate currently on the desirability of publishing additional information about the pupils in the school to put the test results in context (see, for example, McPherson 1992), especially to measure the academic progress they make while at the school rather than just the achievement on leaving. The aggregated results for each classroom (a euphemism for "teacher" in the primary school) will also be made known to the school community.

DISCUSSION AND CONCLUSIONS

The various ways in which judgements of performance are aggregated for National Curriculum Assessment have the result that criterion-referencing cannot be a characteristic of most of the reported scores. As shown above, a typical 7-year-old child will be level 2 in English but this could hide a reading attainment equivalent to a 9-year-old's and a writing attainment equivalent to a 5-year-old's. Fragmenting the curriculum specification only gives rise to true criterion-referencing when the assessment and reporting are also fragmented. More than that, the burdens of assessment and reporting are such that the curriculum specification has had to be constrained to a maximum of five domains (from the 14 and 17 for mathematics and science respectively). This does not mean, however, that the curriculum has itself been cut by two-thirds. At least half the statements of attainment still appear in the new specification, and the net result is that each level of performance is now characterized by more strands and more attributes, making true criterion-referencing that much harder to achieve.

It is too early to judge, especially with the constant changes to curriculum and assessment, whether the way in which the curriculum is specified has had any positive impact on teaching and learning. There is evidence from graded assessment (Pennycuick & Murphy, 1988) and from profiling and records of achievement (Broadfoot et al, 1988) that criterion-referencing demystifies assessment for students (and their parents) and makes it clearer to them what is to be learnt. At the same time, however, part of the success of criterion-referencing can be attributed to making sure that the targets are achievable within a reasonable space of time (not placed two years of normal development apart) and to some element of negotiation between student and teacher about what the targets should be (inevitably missing in a system where all criteria are prespecified).

The validity of the assessment exercise is further threatened when the methods of assessment are radically changed from predominant reliance on performance assessment to predominant reliance on paper-and-pencil tests while the curriculum itself remains unchanged. The chances that the 1992 assessments validly and comprehensively reflect all the objectives of the curriculum are small.

NOTE

For this paper I have drawn extensively on *Monitoring National Standards*, an article I have prepared for the second edition of *The International Encyclopedia of Education* (in press), and on *Assessment in England*, a paper commissioned from me by Pelavin Associates Inc.

REFERENCES

Binkley M, Guthrie J, and Wyatt T (1991) *A Survey of National Assessment and Examination Practices in OECD Countries*. US Department of Education (for OECD), Washington, DC.

Broadfoot P, James M, McMeeking S, Nuttall D, and Stierer B (1988) *Records of Achievement: Report of the national evaluation of pilot schemes*. Department of Education and Science/Welsh Office, London.

Foxman D, Hutchinson D, and Bloomfield B (1991) *The APU Experience 1977-1990*. School Examinations and Assessment Council, London.

Gipps C V and Goldstein H (1983) *Monitoring Children: an evaluation of the Assessment of Performance Unit*. Heinemann Educational Books, London.

Le Guen M (1991) *Measuring to Succeed: national evaluation in France*. OECD, Paris.

McPherson A (1992) Measuring added value in schools, *National Commission on Education Briefing No 1*.

Pennycuick D and Murphy R (1988) *The Impact of Graded Tests*. Falmer Press, Lewes, Sussex (UK).

Stenhouse L (1975) *An Introduction to Curriculum Research and Development*. Heinemann, London.

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Programme of study

Attainment Target 4: Shape and space

Pupils should recognise and use the properties of two-dimensional (2-D) and three-dimensional (3-D) shapes and use measurement, location and transformation in the study of space.

PROGRAMME OF STUDY	STATEMENTS OF ATTAINMENT	EXAMPLES
LEVEL 1		
Pupils should engage in activities which involve:	Pupils should be able to:	Pupils could:
• sorting and classifying 2-D and 3-D shapes using words such as 'straight', 'flat', 'curved', 'round', 'pointed', etc. • building 3-D solid shapes and drawing 2-D shapes and describing them. • using common words, such as 'on', 'inside', 'above', 'under', 'behind', 'next to', to describe a position.	a) Talk about models they have made.	*Make various constructions, models or pictures from a range of materials and describe them.*
• giving and understanding instructions for movement along a route.	b) Follow or give instructions related to movement and position.	*Follow directions in a PE lesson, or on an errand around school.* *Follow signed instructions or cards displaying symbols for 'over', 'under', 'on', 'in', etc in using an obstacle course or maze in PE.* *Give instructions to direct a simple programmable toy.*
• comparing objects and ordering objects and events without measuring, using appropriate language.	c) Compare and order objects without measuring.	*Use language such as 'long', 'longer than', 'longest'; 'tall', 'taller than', 'tallest'; 'heavy', 'light'; 'before', 'after'.*

LEVEL 2

- recognising squares, rectangles, circles, triangles, hexagons, pentagons, cubes, rectangular boxes (cuboids), cylinders and spheres and describing their properties.
- recognising right-angled corners in 2-D and 3-D shapes.
- recognising types of movement: straight (translation), turning (rotation).
- understanding angle as a measurement of turn.
- understanding turning through right angles.
- understanding the conservation of length, capacity and 'weight'.

a) Use mathematical terms to describe common 2-D shapes and 3-D objects.

Create pictures and patterns using 2-D shapes and describe them.

Describe 3-D objects using appropriate language.

b) Recognise different types of movement.

Rotate body through 1, 2, 3 and 4 right angles.

Turn to left or right on instructions (in PE, games using turtle graphics or programmable toys).

LEVEL 3

- sorting 2-D and 3-D shapes and giving reasons for each method of sorting.
- recognising (reflective) symmetry in a variety of shapes in two and three dimensions.
- using and understanding compass bearings and the terms 'clockwise' and 'anticlockwise'.

a) Sort shapes using mathematical criteria and give reasons.

Sort shapes with a square corner, shapes with curved edges and shapes with equal sides or faces, giving appropriate explanations.

b) Recognise reflective symmetry.

Explore patterns from a variety of world cultures, eg Islamic, Japanese.

Study shapes and identify some lines and planes of symmetry.

Explore patterns in art or PE.

c) Use the eight points of the compass to show direction.

Describe wind direction from a weather vane.

Describe locations of places in the neighbourhood of the school, using compass points.

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AT4

PROGRAMME OF STUDY	STATEMENTS OF ATTAINMENT	EXAMPLES
LEVEL 4		
• constructing simple 2-D and 3-D shapes from given information and knowing associated language.	a) Construct 2-D or 3-D shapes and know associated language.	*Construct rectangles, circles, nets for cubes, pyramids and prisms.*
		Know 'acute', 'obtuse', 'reflex', 'parallel', 'perpendicular', 'vertical', 'horizontal', etc.
• reflecting simple shapes in a mirror line.		
• understanding the congruence of simple shapes.		*Design and make a container for an awkwardly shaped object, eg 'Santa's lost boot'.*
• understanding and using language associated with angle.		
• specifying location by means of co-ordinates in the first quadrant and by means of angle and distance.	b) Specify location.	*Locate features on an ordnance survey map given their grid references.*
		Use turtle graphics instructions for distances and direction.
• recognising rotational symmetry.	c) Recognise rotational symmetry.	*Confirm the rotational symmetry of shapes using tracing paper.*
• finding perimeters of simple shapes.	d) Find perimeters, areas or volumes.	*Identify different rectangles with the same perimeter.*
• finding areas by counting squares, and volumes by counting cubes.		*Compare the areas of leaves using a transparent square grid.*
		Work out the approximate volumes of small boxes.
		Work out how many different rectangles can be made from 24 tiles. What is their area and perimeter?

AT4

LEVEL 5

- measuring and drawing angles to the nearest degree.

- explaining and using properties associated with intersecting and parallel lines and triangles, and knowing associated language.

- identifying the symmetries of various shapes.

- using networks to solve problems.

- specifying location by means of co-ordinates in four quadrants.

- finding areas of plane figures (excluding circles), using appropriate formulae.

- finding volumes of simple solids (excluding cylinders), using appropriate formulae.

- finding the circumference of circles, practically, introducing the ratio π.

a) **Use accurate measurement and drawing in constructing 3-D models.**

Construct prisms.

Make a pyramid-shaped gift box of given dimensions.

b) Use properties of shape to justify explanations.

Give reasons when identifying equal angles in a diagram.

Find the centres, axes and planes of symmetry in a variety of plane and solid shapes.

c) Use networks to solve problems.

Find the shortest route for a person delivering the post.

d) Find areas of plane shapes or volumes of simple solids.

Know and use the formulae for finding the areas of squares, rectangles, triangles.

Find the volumes of cubes, cuboids and triangular prisms.

PROGRAMME OF STUDY	STATEMENTS OF ATTAINMENT	EXAMPLES
LEVEL 6		
• recognising and using common 2-D representation of 3-D objects.	a) Use 2-D representation of 3-D objects.	*Use isometric paper to represent 3-D objects.*
• enlarging a shape by a whole number scale factor. • classifying and defining types of quadrilaterals. • knowing and using angle and symmetry properties of quadrilaterals and other polygons. • using computers to generate and transform 2-D shapes. • devising instructions for a computer to produce desired shapes and paths.	b) Transform shapes using a computer, or otherwise.	*Enlarge a shape to fit neatly into a given rectangle.* *Use transformations and symmetry properties to produce tessellations.*
• understanding and using bearings to define directions.	c) Understand and use bearings to define direction.	*Use bearings in real-life examples, such as describing the position of a ship or aircraft or the location of a buoy.*
• finding areas of circles using the formulae.	d) Demonstrate that they know and can use the formulae for finding the areas and circumferences of circles.	*Find the radius of a circle with the same area as a square of side 5cm.* *Calculate how many times the wheels of a bicycle rotate in a journey of 5km if the radius of each wheel is 34cm.*

AT4

LEVEL 7

- using co-ordinates to locate position in 3-D.

a) Use co-ordinates (*x*, *y*, *z*) to locate position in 3-D.

Find some of the possible locations of the vertices of a cuboid of dimensions 4, 2, 1 if the position of one vertex is (3, 2, 0).

- determining the locus of an object moving subject to a rule.

b) Determine the locus of an object which is moving subject to a rule.

Find the locus of points equidistant from two fixed points.

Find the locus of points whose sum of distances from two fixed points is constant.

Predict the relative movements of parts in a simple linked-cog or pulley system.

- understanding and applying Pythagoras' theorem.

c) Use Pythagoras' theorem.

Find the distance between two points expressed as co-ordinates.

- using knowledge and skills in length, area and volume to carry out calculations in plane and solid shapes.
- enlarging a shape by a fractional scale factor.

d) Carry out calculations in plane and solid shapes.

Calculate lengths, areas and volumes in shapes involving rectangles, triangles, parallelograms, circles, trapezia, cubes, cuboids, cylinders and other solids of constant cross-sectional area.

LEVEL 8

- understanding and using mathematical similarity; knowing that angles remain unchanged and corresponding sides are in the same ratio.

a) Use mathematical similarity to solve problems.

Calculate the effect of enlargement on linear dimensions.

Adapt a company logo for use on a poster, stationery and business card.

- using sine, cosine and tangent in right-angled triangles, in 2-D.

b) Use sine, cosine or tangent in right-angled triangles.

Use sine, cosine or tangent to work out lengths and angles in plane figures.

- distinguishing between formulae for perimeter, area and volume by considering dimensions.

c) Distinguish between formulae by considering dimensions.

Recognise that πd is a linear measurement and that πr^2 is an area measurement.

Identify from a range of formulae such as $4 \pi r^2$, $4 \pi r^3/3$, $\pi r^2 h/3$, and $r(\pi + 2)$ those which denote (say) volume.

- understanding and using vector notation, including its use in describing translations.

PROGRAMME OF STUDY	STATEMENTS OF ATTAINMENT	EXAMPLES
LEVEL 9		
• calculating distances and angles in solids using plane sections and trigonometric ratios.	a) Carry out more complex calculations in plane or solid shapes.	*Find the angle that the edge of a square-based pyramid makes with its base.*
• understanding the conditions for congruent triangles.		*Prove that two triangles are congruent by reference to corresponding properties.*
• understanding and using the relationship between surface areas of similar figures and volumes of similar 3-D solids.		*Make an accurate set of drawings for making a piece of jewellery incorporating several different polyhedra.*
• calculating lengths of circular arcs and areas of shapes whose perimeters include circular arcs; calculating the surface area of cylinders and volumes of cones and spheres.		*Explain how many interlocking cubes will be needed to enlarge a model made with seven cubes by a given scale factor.*
		Calculate the area and perimeter of a sector of a circle (radius 12cm) when the angle at the centre is 35 degrees.
• understanding and using the laws of addition and substraction of vectors.	b) Use vector methods to solve problems.	*Find the resultant force when an object is pulled in two directions.*
		Calculate the wind speed, given the actual velocity of an aeroplane and its velocity in still air.
• finding sine, cosine and tangent of angles of any size.	c) Use sine, cosine or tangent with angles of any size.	*Draw the graphs of $y = 10 \sin x°$, $y = 6$ and $10y + x = 50$. Use these to solve the equations $5 \sin x° = 3$ and $100 \sin x° = 50 - x$.*
• sketching the graphs of sine, cosine and tangent functions for all angles.		
• generating trigonometric functions using a calculator or computer and interpreting them.		

LEVEL 10

knowing and using angle and tangent properties of circles.

using sine and cosine rules to solve problems including simple cases in 3-D.

understanding how transformations are related by combinations and inverses.

using matrices to define transformations in 2-D.

a) Solve problems in 2-D or 3-D.

Using computer software or otherwise, find one transformation which is equivalent to successive applications of two given transformations.

Calculate the distance between two ships 30 minutes after they leave port together, if they move at constant speeds in the direction 060° and 100°, respectively, the first ship moving at 20km/h and the second at 24km/h.